IV

RECENT ADVANCES IN UTILIZATION OF ANIMAL FATS*

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One of the most reliable ways for looking into the future for any industry consists in reviewing prior developments and locating its present position as precisely as possible. In view of its importance and present depressed condition, it seems especially worthwhile to do this for the animal fat industry.

Economic and Technological Background

Because of the glamour which has been attached to the growth of certain segments of the vegetable oil industry, many of us are inclined to forget that animal fats still contribute almost half of the total fat and oil production in the United States.

Nearly 3 billion pounds of edible animal fats, chiefly lard, are produced each year in the United States. In addition we produce approximately 2-1/4 billion pounds (over one million tons) of inedible fats as a by-product of the livestock industry. It is desirable to keep firmly in mind this by-product status of the animal fats. Increased demand for meats resulting from both dietary improvement and increasing population has been an important factor in the increased production of these fats. Production data are shown in Table 1.

Table 1 - Production of Animal Fats and Oils[1]

Year	Lard	Inedible Tallow and Grease
	(Billions of lbs.)	
Av. 1937 - 41	2.09	1.30
1947	2.32	1.98
1948	2.50	2.10
1949	2.63	2.15
1950	2.85	2.34
1951	2.93	2.25[2]

1. Fats and Oils Situation 153, 5 (1952)
2. Agricultural Statistics, 1952.

* Contribution from the Eastern Regional Research Laboratory, Philadelphia 18, Pa. One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U.S. Department of Agriculture.

Traditionally this abundant supply of fats has found its principal outlet as lard (edible) and for use in the manufacture of soap (inedible) and other cleansing agents. Technological developments in recent years have resulted, however, in the introduction of competitive materials from other sources which have found substantial favor with consumers. In studying the effects of these developments it is interesting to compare the flow of fats into the soap kettle with the sales of synthetic detergents for the past few years. These data are shown in Table 2.

Table 2

Year	Tallow and Grease[1] Consumption in Soap	Bulk[2] Detergent Production
	(Billions of lbs.)	
Av. 1937 - 41	1.16	0.18
1947	1.88	0.7
1948	1.78	.98
1949	1.66	1.08
1950	1.81	1.20
1951	1.66	

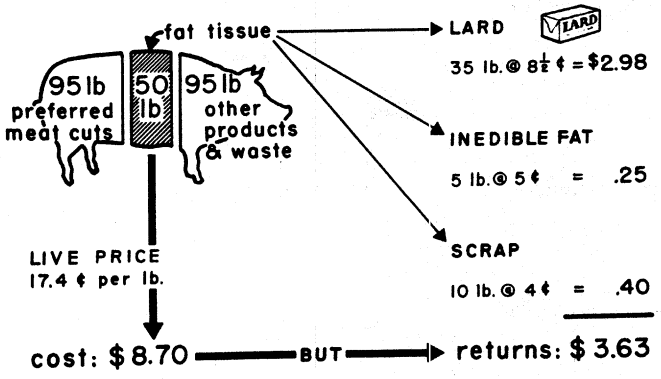
1. Fats and Oils Situation 156, 25 (1952)
2. J. W. McCutcheon, Report to the U.S. Department of Agriculture.

From these data it can be seen that detergent production has increased enormously during the past decade. At the same time it is apparent that the consumption of fats in soap has failed to keep pace with increased fat production and increased population. About a year ago it was estimated that about 350-400 million pounds of inedible fats are being produced which have no ready domestic use. Exports in 1952 of about 700 million pounds indicate this figure may be conservative at present.

Statistics regarding the consumption of edible fats, chiefly lard, are not so revealing because this product continues to find use; it continues to find use, however, only at substantial sacrifice in income to the livestock industry as is shown in Figure 1, which is discussed below.

The economic effects resulting from this contraction of effective utilization of animal fats have been apparent for some time particularly in the margin between the cost of the live animal and the value of the fat produced from it. It is interesting to briefly review the picture as it pertains specifically to the pork producing segment of the livestock industry. The average hog marketed in the United States weighs about 240 pounds. November 17, 1952 top hogs in Chicago brought $17.40 cwt. or $41.76 for this average hog. After slaughter this average hog can be expected to yield about 35 pounds of lard worth (the same day on the Chicago market at $0.0855 per pound) $2.98. In addition this same hog will yield about 5 pounds of inedible fat (grease) worth the same day not more than $0.25 ($0.05 per pound). Rendering these fatty tissues also yields an estimated 10 pounds of meat scrap which at $0.04 per pound brings $0.40. Summarizing we find that 50 pounds of fatty tissue from the average hog costs $8.70 but returns only $3.63. Economists tell us that the price of meat is fixed by the laws of supply and demand and that the resulting deficit of $5.07 per hog must result in the farmer being

paid that much lower prices for his hogs. Since about 75,000,000 hogs are slaughtered annually in the United States the reduced income of farmers resulting from low fat prices is estimated to cost them approximately $400 million per annum.



DIFFERENCE, $5.07/HOG, MUST COME FROM LOWER PRICE TO FARMER

(75 MILLION HOGS SLAUGHTERED ANNUALLY)

ALL PRICES TOP WHOLESALE AT CHICAGO, NOVEMBER 17, 1952

Figure 1. Effect of Reduced Demand for Animal Fats

The figures are especially depressing because lard is an edible product which has many advantages over crude vegetable oils as a starting material for shortening manufacture. Yet on the same day, November 17, 1952, it was bringing about 60 per cent as much as crude cottonseed oil ($0.13-7/8 per pound) and about 70 per cent as much as crude soybean oil ($0.1175 per pound, Decatur, Illinois).

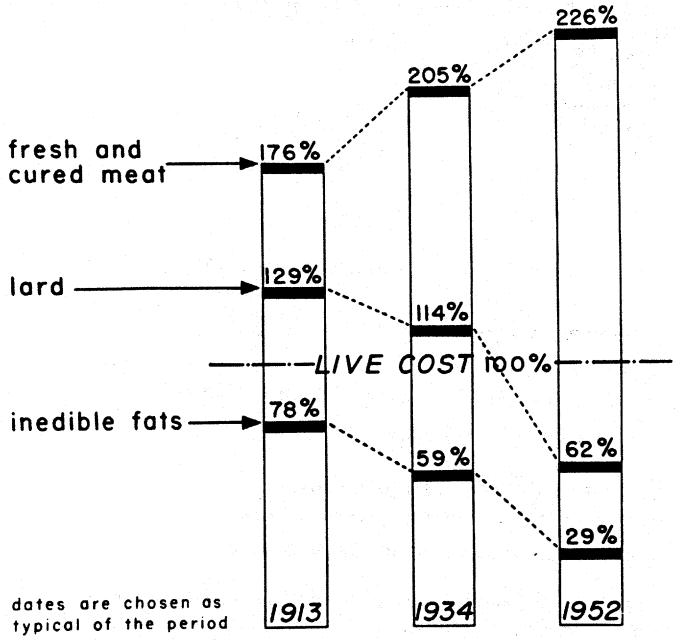
The corresponding picture for fats derived from cattle and sheep shows an even greater discrepancy with respect to the per pound price of the animals at the packing plant and the return derived from their fatty tissues. In the first place the price per pound of cattle and lambs ($34.25 and $22.50 per cwt. respectively, Chicago, November 17, 1952) is usually greater than for hogs. Secondly, most of the tallow from these animals is inedible and consequently commands a considerably lower price than lard (Fancy tallow, $0.0588, November 17, 1952). Hence, although statistics are not available to us in the form necessary to make the detailed calculations shown for lard above, it seems certain that the deficit of income from fatty tissues of beef and sheep must be of the same order of magnitude as that from lard or grease.

Current Surplus Situation

It should be added that the price pattern, unfortunate as it is, fails to tell the whole story. Because of the shortage of domestic outlets the industry has become increasingly dependent upon the export market; it is reliably estimated exports of tallow and grease during 1952 were about 700,000,000 pounds.

This picture has not always prevailed. Until the last few years, the average price of lard was very close to, and much of the time exceeded,

that of hogs, and prior to 1920 this was also true for inedible tallow as shown in Figure 2. As noted above, the present picture has slowly developed following the introduction of competitive materials from other sources which have found substantial favor with consumers.



data from the bureau of agricultural economics, (u.s.d.a.)

Figure 2. Trend in Pork Product Prices

Since production of by-product fats cannot readily be substantially curtailed, the nature of the action to be taken in order to bring about improvement in this important segment of the livestock industry becomes "the $64 question." Although several suggestions have been made, the one most frequently heard and the one discussed below is research. This constitutes a logical answer in at least one respect because most, if not all, of the competitive materials which are displacing animal fats have originated through research. Research to date on animal fats has not been conducted on the same scale as similar research on such competitive materials as petroleum, coal tar and even vegetable oils. Therefore, animal fats have been unable to keep up the competitive pace.

Since research can take several directions, it is well to review very briefly past accomplishments in order to have knowledge of specific directions in which there have been indications of progress.

One interesting trend in the edible fat field is shown by statistics regarding the increased use of animal fats in shortenings. These are shown in Table 3. These statistics show a rapidly growing tendency to convert lard into shortening; in fact, such conversion has increased tenfold in the 6 years shown. It seems certain that when complete figures are available for 1952 a substantial further increase will be shown since during the latter part of the year the conversion rate was over 300 million pounds per year. It is worth noting that this phenomenal increase in the use of lard in short-

Table 3 - Fats and Oils Used in Manufacture of Shortening[1]

(Millions of lbs.)

	Av. 1937-41	1946	1947	1948	1949	1950	1951
Lard	16	20	101	114	127	177	206
Tallow, Edible	55	44	44	29	18	17	13
Oleostearin	26	13	19	15	12	14	9
Oleo Oil	1	1	1	1	--	--	--

1. Fats and Oils Situation 156, 22 (1952)

ening has been made possible by research; research which led to discovery of the antioxidants being used and methods for controlling the texture and physical properties of the products. These statistics also support the contention of a number of chemists that the basic scientific information necessary to prepare a satisfactory shortening from animal fats including lard is substantially all availabe.

One recent development which offers some promise for increased utilization of animal fats is the development of acetoglycerides. These compounds now being actively investigated at the Southern Regional Research Laboratory as well as at a number of industrial laboratories, have unusual physical properties seldom found in fatty materials. Hence, although it may be too early to predict exact outlets, this interesting class of compounds promises to find substantial utilization in those fields of use where these unusual physical properties are valuable.

In view of the fact that modern science has tended to make fats and oils interchangeable within broad limits, one wonders why more edible animal fats are not finding outlet in such rapidly growing fields as margarine, salad dressings and the like. The experience shown above in developing shortenings from animal fats might indicate considerable possibility for success in these additional markets provided sufficient research and sales effort were put into the problem.

Let us now turn our attention to the inedible animal fats. The principal inedible fats, other than those used in the drying oil industry are tall oil, vegetable oil "foots" obtained as a by-product from the caustic refining of such edible fats as cottonseed and soybean oil, and those animal fats obtained as an important by-product of meat production, inedible chiefly for aesthetic reasons. Of these three raw materials, the inedible animal fats are by far the most important volume-wise. All fats consist almost exclusively of chemical combinations of a mixture of fatty acids and glycerol. Upon hydrolysis, animal fats yield approximately 90 per cent fatty acids and 10 per cent glycerol. The fatty acids largely determine the uses to which these fats may be put. In recent years about 80 to 85 per cent of the inedible animal fat has been consumed in the manufacture of soap, with glycerol as a by-product. Most of the rest has gone into the production of fatty acids and glycerol (10 per cent), and lubricants and lubricating greases (5 per cent). The small remainder has been used in many miscellaneous applications.

In spite of the multiplicity of uses for inedible animal fats, it has become apparent that new uses are urgently needed to keep the industry healthy. For reasons given above this is true even during periods of high industrial activity. Again as in edible fats there is certain merit in estimating future trends only after consideration of past trends. This may be done by reviewing the information in Table 4.

These data show that although domestic disappearance of fats in soap

Table 4 - Domestic Disappearance of Fats[1]

(Billions of lbs.)

	Av. 1937-41	1946	1947	1948	1949	1950	1951
Soap	1.88	1.86	2.35	2.14	1.83	1.87	1.60
Drying Oils	.85	.92	.98	1.05	.86	1.05	1.05
Other Industrial Products	.52	.87	.88	.82	.96	1.17	1.19

1. Fats and Oils Situation 156, 25 (1952)

is decreasing and use in drying oils shows only a nominal increase, the use in "other industrial products" during the past decade shows a tremendous growth of about 140 per cent. Items included in the category "other industrial products" are principally fatty acids and their derived chemical products, fat equivalent of soap used in manufacture, principally for synthetic rubber and textiles, fats used in metallurgical processing and lubricant uses and the like. It is well to examine the category of uses further to see what contributions have been made by research to this growing industrial use.

We find that such an improvement has resulted already from co-operative research carried out under the superivision of The Rubber Reserve Company. This research has led to the development of a special soap essentially free of polyunsaturated fatty acid components and, therefore, superior for use as an emulsifier in synthetic rubber manufacture. There seems to be little doubt that this development has served to retain a substantial proportion of this market currently estimated to be about 30 million pounds per year for tallow, while at the same time it has resulted in improved products and important economies for the rubber industry.

The development of the first commercially feasible procedure for the preparation of an improved grade of oleic acid is an example of the development of new products to fill requirements not met by previously available fat derivatives. This product, first described by research workers of the Eastern Regional Research Laboratory in 1945 is derived from inedible tallow or grease as the starting material. Since 1949, improved oleic acid production has been a commercial operation and the product is now available from several producers. Demand for this product is reported to be increasing steadily; in fact, its availability is already facilitating the production of other products, notably azelaic acid having large potential usage which, however, could not be made economically from ordinary red oil.

Thus we see by these examples that research does offer considerable promise for eventually altering the present unhappy status of animal fats. In fact it can be stated that bad as it is, the present situation would undoubtedly be worse if it were not for research already done. On the other hand, it must be borne in mind that just as a considerable span of years was required to develop products responsible for the present competition for animal fats, the answers obtainable by research will require considerable time.

A relatively large number of additional possibilities exist for increasing market outlets for animal fats by research. Possibly this may best be demonstrated by briefly outlining the research program on animal fats which we are carrying out in our own laboratories or by contract.

Important problems being investigated at present include:

1. Preparation of shortenings from edible animal fats, particularly lard.

2. Production of improved lard oil, both edible and inedible.
3. Use of domestic animal fats in hot dip tinning.

This work was carried out co-operatively under contract with the Armour Research Foundation, Chicago, Illinois. A final report of these results is now being prepared. Research and development is also being done at present looking to the use of domestic fats as a lubricant for use in the production of cold rolled steel sheet.

4. Stable feed mixes for dogs and broilers containing larger proportions of animal fats than have previously been generally used.

This work is being carried out under contract with the American Meat Institute Foundation Laboratories at the University of Chicago. A Bulletin has been released describing the results of this work to date and further reports will be issued as the results may justify.

5. Development of competitive synthetic detergents from domestic fats.
6. Preparation of vinyl derivatives of fats which may permit extensive increase of their use in plastics.

Basically this represents a research effort to develop methods for using fat derivatives to prepare internally modified polymers. The portion of these studies concerned with pilot plant preparation of vinyl esters and ethers of fatty acids and alcohols, respectively, has been carried out under contract with General Aniline and Film Corporation at Easton, Pennsylvania.

7 Development of improved plasticizers from fats with particular reference to products compatible with the plastics in extensive commercial use.

As a result of this work new stabilizing plasticizers having special value for use with chlorine containing plastics are now in commercial production. These stabilizing plasticizers are epoxidized oils and epoxidized fatty esters. They are prepared by a relatively simple chemical process which involves controlled oxidation of the fat with a per-acid prepared by interaction of hydrogen peroxide and acetic acid or formic acid. The potential market for these plasticizers is large since 150 million to 200 million lbs. of stabilizers and plasticizers are currently being used with vinyls.

8. Preparation of hydroxy acids by direct addition of formic acid at the double bond.

This reaction, recently discovered at the Eastern Regional Research Laboratory, offers a simple direct method for preparing potentially valuable hydroxy acids from domestic fats. The potential significance of this reaction may be realized by consideration of the fact that castor oil is characterized by the fact that it consists largely of the glycerides of an hydroxy acid.

Besides the work being done in the Regional laboratories on utilization of animal fats a very substantial amount of research and development work is being done, of course, in private and industrial laboratories. Probably one of the most significant recent developments is the announcement by a fatty acid producer of their plans to convert oleic acid to azelaic acid. The process, reported to involve ozonization of oleic acid, promises to make the dibasic acid available at a price which permits its consideration for use in a wide variety of applications. It is generally known that considerable industrial research effort is being directed toward development of competitive processes for converting oleic acid to dibasic acids. The extent to which currently produced dibasic acids are in demand indicates that developments

along these lines may lead to important consumption of oleic acid for conversion to dibasic acids.

Considerable attention continues to be given by industrial research workers to the development of synthetic detergents derived from animal fats. It seems probable that tallow alcohols are being used as a partial replacement for lauryl type alcohols in a widely sold household detergent. The production of tallow alcohols is currently being explored on a commercial scale by several concerns. Because of the current low prices of tallow it is desirable to reinvestigate a number of processes for preparing detergents from tallow derivatives and it may be assumed this is being done.

In the food fat field considerable progress is being made commercially in improving the physical properties of lard. One of the most recent methods for doing this is the so-called "rearrangement" of lard. This is generally accomplished by treatment with a metal alcoholate such as sodium methoxide.

The availability of antioxidants which are generally suitable together with better methods for improving their physical properties brings closer the day when animal fats are completely interchangeable with vegetable oils in shortening. In view of this, price differentials between lard and crude vegetable oils do not seem justifiable to the chemist.

In addition to work aimed at contributing to increased utilization of fats in all of the above diverse fields it is desirable that a substantial amount of fundamental research be carried out simultaneously. It is only in this manner that we can hope to continue to open new avenues for investigation along the more practical lines of utilization research.

In our own laboratories at present these fundamental studies are following the principal lines enumerated below:

1. Oxidation of fats and the chemical nature of the products formed.
2. Glyceride structure of fats.
3. Composition studies and development of new analytical tools.

In addition the U.S. Department of Agriculture is supporting certain fundatmental studies by contract. Dr. Arthur Rose at Pennsylvania State is engaged in studying the distillation characteristics and vapor pressures of fatty acids and their derivatives. An additional contract calling for study of solubilities of fatty acids and their derivatives has been awarded to the Hormel Foundation of the University of Minnesota.

It is our belief that this strong fundamental research program, supported and followed by utilization research cannot fail to make substantial contributions toward development of new outlets and uses for the animal fats which we have available.